Resource assessment using GIS modelling of orogenic gold mineralisation and wind energy potential in Wellington, New Zealand.

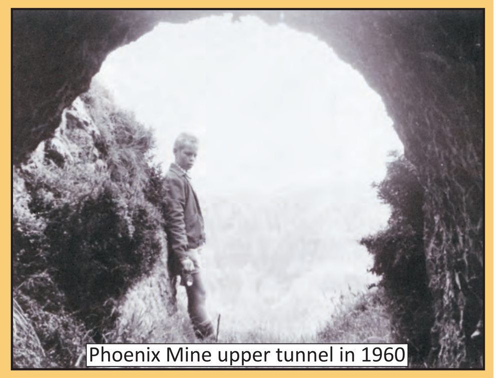
Matthew P. Hill[1] & Katie J. Peters[2]
[1]Kenex Pty Limited, Perth, Australia
[2]Kenex Limited, Wellington, New Zealand

Kenex — Creating opportunities in the spatial world

Introduction

We have used GIS spatial modelling over the Wellington area to find ideal locations for orogenic gold exploration and wind farm development. This was done to find potential exploration targets, assess the most suitable use for the land and to illustrate how predictive modelling in a GIS can be used to assist with land management.

Cutting-edge environmental and terrain modelling as well as a wealth of historic geological research has been used to create predictive variables to identify orogenic gold deposits and wind turbine sites. By combining this data using spatial modelling techniques we have generated targets that can be used by gold and wind explorers to undertake fast assessment of prospectivity in a region as well as modelling of economic value and designing of exploration programmes. These models are particularly useful for regional land management studies.

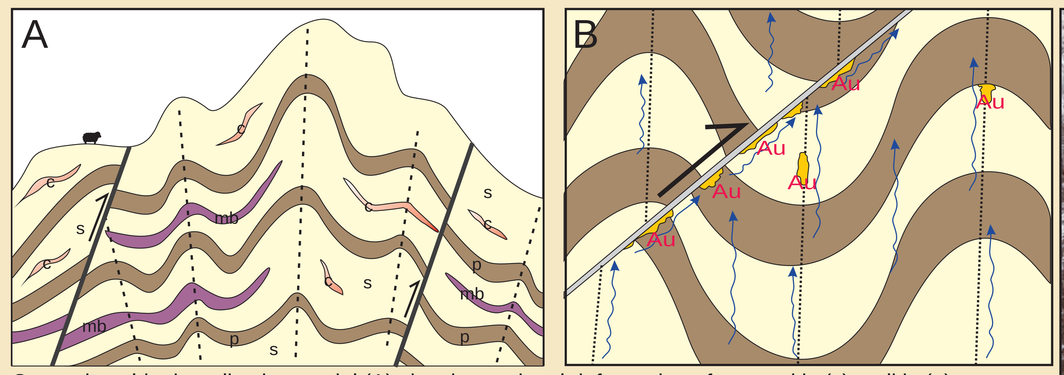

Phoenix Mine upper tunnel in 1960


Wind turbines at Meridians Project West Wind

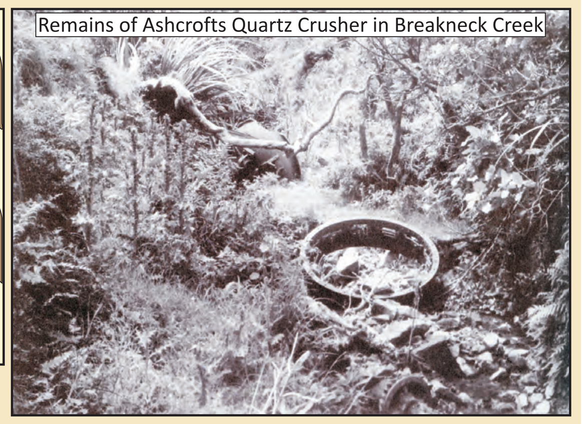
Wellington Goldfields & Orogenic Gold

The southwest region of Wellington encompassing the Terawhiti, Makara and Karori mineral fields has undergone mining for gold since the 1850's. This included an initial phase of alluvial mining followed by mining of quartz reefs in the 1880's and again in the 1900's with some renewed exploration in the 1980's. There is currently no exploration for gold in this region and there are only a few small historic adits visible in the hillsides along with remnants of historic tramways and battery equipment from 100 years ago.

An orogenic deposit model is proposed for the concentration of gold in the Wellington region. The metamorphism and deformation of the basement terrane to greenschist facies produced fluid which transported and concentrated gold from within the sedimentary pile into structural traps. Wellington is similar to other Mesozoic orogenic gold terranes such as Marlborough and Otago. Schistose rocks in these terranes are one of the key lithological targets for gold exploration in New Zealand and host deposits such as Macraes Flat in Otago.

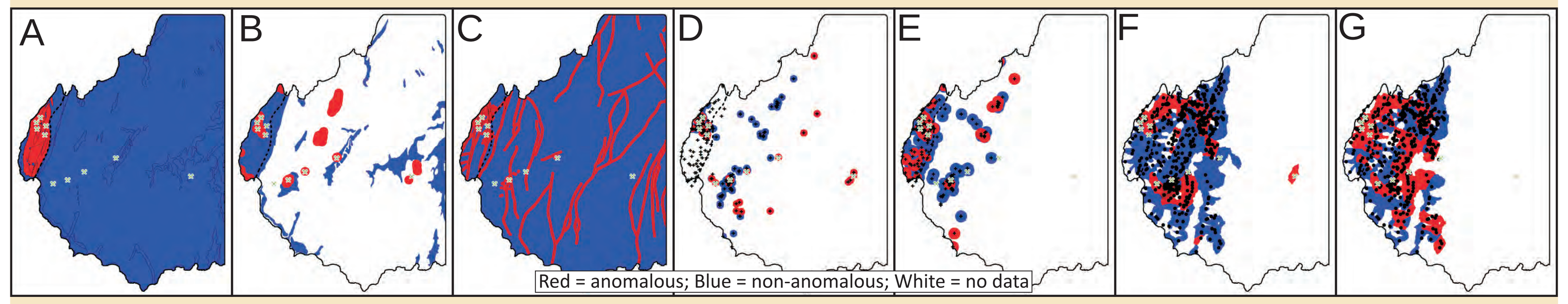


Orogenic gold mineralisation model (A) showing regional deformation of psammitic (s), pelitic (p), meta-basalt (m) and chert (c) sediments; and fluid flow along structures leading to the deposition of gold (B).


Remains of Ashcrofts Quartz Crusher in Breakneck Creek

The mineral systems concept was used to define the parts of the deposit model which are critical for ore-forming processes. We have generated predictive maps of possible metal sources in the region, structures that could be used for fluid migration and ideally suited to host a mineral deposit, and outflow zones which may indicate a subsurface deposit.

Source rocks and energy are mapped from deformed greenschist facies rocks which have released fluids during short lived thermal events. Areas where this fluid flow may have occurred in high volume are located from mapped quartz veins and quartzites. Fold hinges and faults acting as structural pathways for the fluids have precipitated out quartz-carbonate veins with gold in late-stage brittle fracturing. These structural conduits and traps have been mapped by determining faults and folds active during the Mesozoic and from rock chip samples anomalous in gold. Outflow zones were mapped using anomalous pathfinder geochemistry in rock chips, stream sediments, and soil samples.



Geological data used in the orogenic gold model. Source, energy & fluids represented by textural zone >2a greenschists (A) and mapped veins and quartzites (B); Pathways represented by Mesozoic faults and folds (C); Traps represented by anomalous Au-bearing rock chips (D); and Outflow represented by anomalous pathfinder element bearing rock chips (E), anomalous stream sediment and soil sample Au (F) and anomalous pathfinder element bearing stream sediments (G).

Acknowledgements

B. Walter, S. Faulkner, M. Green (Aurecon) are thanked for their assistance in developing the terrain modelling techniques and allowing us to use their Wellington mesoscale wind speed data. Geologists at Kenex are thanked for developing the digital databases underpinning the spatial models in this study. GNS Science PETLAB, GERM and Active Fault databases were used in this study. References in this poster can be found in the accompanying paper (Hill and Peters, 2010 - AusIMM Conf. NZ). The three historic photographs in this poster are from "Terawhiti and the Goldfields", Brodie (1986).

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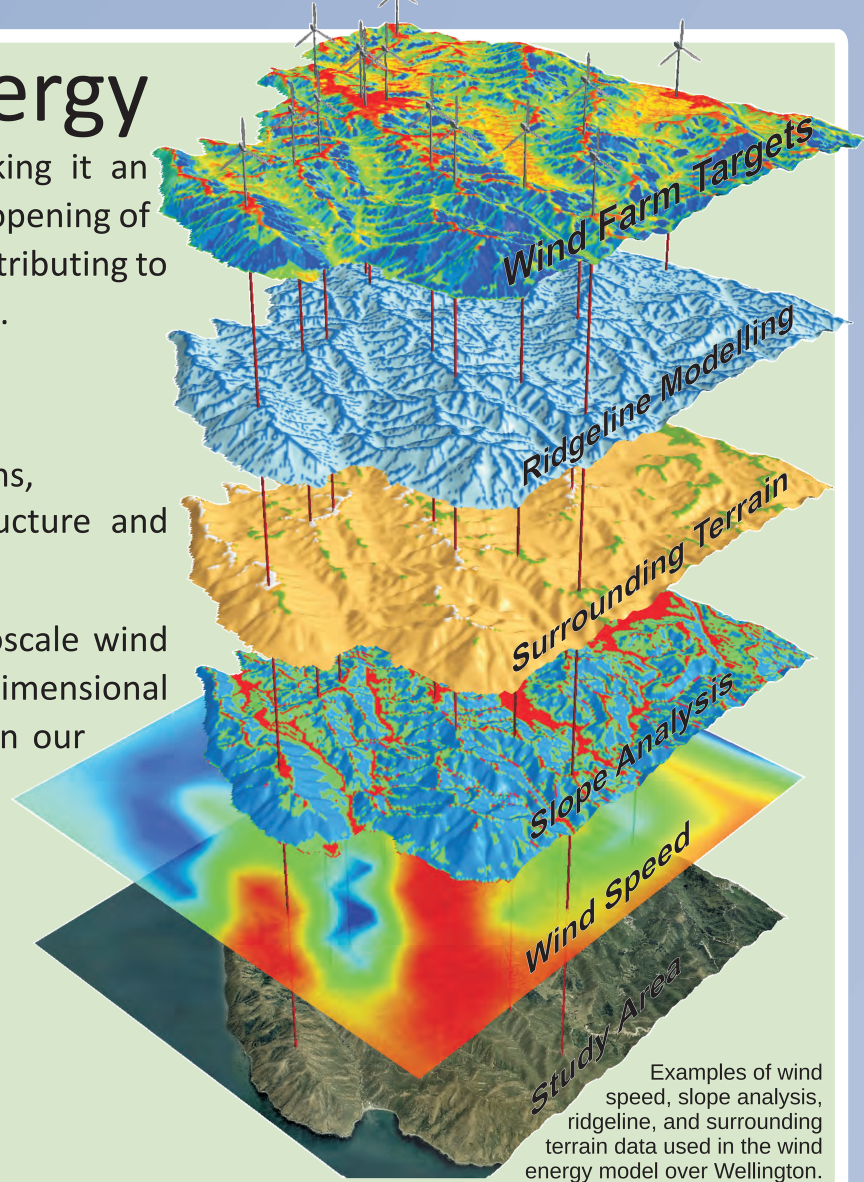
Wellington Wind Energy

Wellington has a world class wind resource making it an important region for wind energy. With the recent opening of Meridians Project West Wind the area is already contributing to New Zealand's goal of 90% renewable energy by 2020.

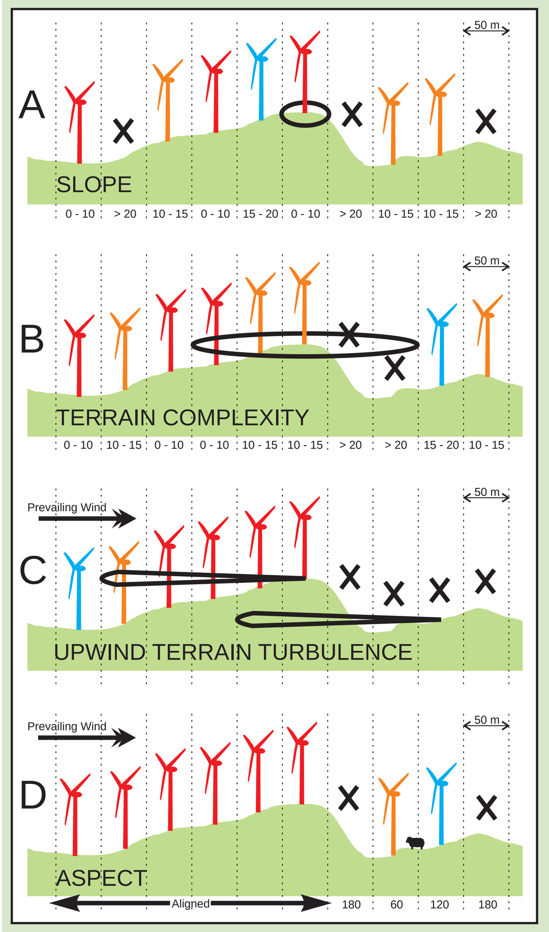
Our three stage wind prospecting approach:

- determines the **wind resource** available at a site,
- analyses the **terrain** to find the best turbine positions,
- and assesses **site suitability** based on infrastructure and environment.

We use wind speed and direction data from mesoscale wind modelling developed by Aurecon using three-dimensional models simulating airflow over complex terrain. In our model we classify the wind speed into ranges suitable for modern wind turbines and use the wind direction data in our terrain analysis.



Examples of wind speed, slope analysis, ridgeline, and surrounding terrain data used in the wind energy model over Wellington.

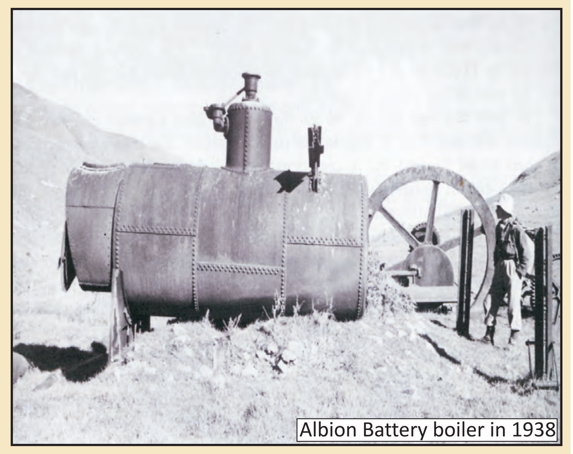


Terrain affects construction costs and economic performance. We use digital elevation models and expert knowledge about wind farms to create predictive maps of slope, aspect to main wind direction, terrain complexity, ridgelines, and turbulence effects from upwind terrain features. Classifying these maps based on modern wind turbine requirements allows us to map ideal terrain locations.

Other parameters related to infrastructure, people, and the environment need to be considered. Our modelling includes predictive maps that locate areas close to existing roads and transmission lines and at a distance from populated areas, environmentally sensitive locations, or high elevations.

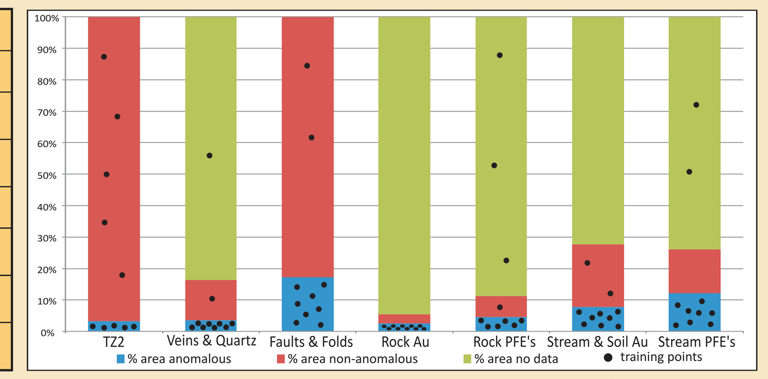
Weights of Evidence Spatial Modelling

We have used weights of evidence (WoE) modelling to combine the predictive maps for orogenic gold. Ten gold deposits from the Wellington region have been used as training points to statistically evaluate and weight input maps in the model. Seven maps were used representing all elements of the mineral system. Maps that best predict mineralisation have a small anomalous area and contain many training points; whereas maps which are less predictive have larger anomalous areas and contain fewer training points. The weighted maps are combined to form a single map which shows prospectivity for orogenic gold in Wellington.


Albion Battery boiler in 1938

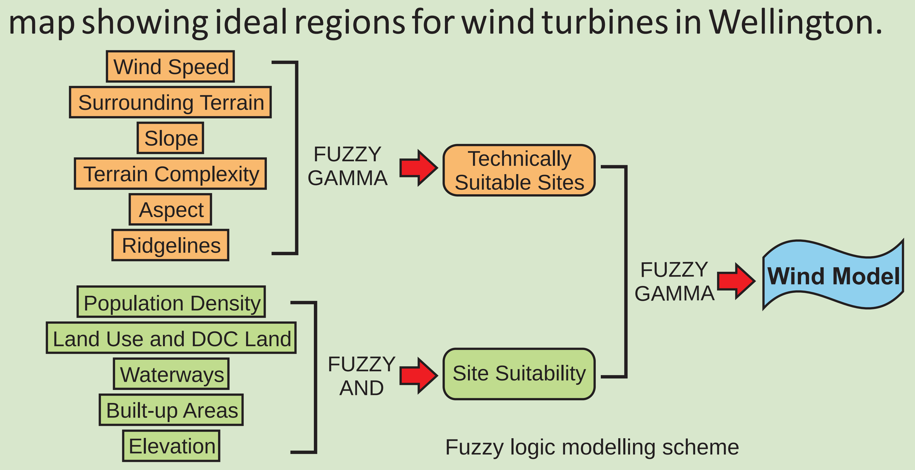
Min. Sys.	Layer	Description	C	StudC
Source, energy & fluids	TZ2	Textural Zone > 2a rocks (greenschists)	3.59	5.39
	Vein & Quartzites	Mapped veins and quartzites buffered to 300 m.	3.65	3.36
Pathways	Faults & Folds	Mesozoic faults and folds buffered to 100 m.	3.02	3.80
Traps	Rock Au	Rock chip samples Au > 0.5 ppm buffered to 250 m.	7.60	0.76
Outflow	Rock PFE's	Anomalous rock pathfinder elements (PFE) As, Cu, Ni, Mo, & Zn buffered to 400 m.	2.30	2.09
	Stream & Soil Au	Catchments with stream sediment samples Au > 60 ppb & soil samples (200 m buffer) with Au > 25 ppb.	2.44	3.04
	Stream PFE's	Catchments with stream sediment samples anomalous in Ag, As, Cu, Pb & Zn.	6.71	0.67

Orogenic gold predictive maps and WoE statistics.


Graphic representation of area and training point distribution.

Fuzzy Logic Spatial Modelling

Fuzzy logic modelling was used to combine the predictive maps for wind energy. This method requires expertly assigned weights representing the importance of each element in the predictive map. Important map classes such as ideal wind speed or slope can have a higher weighting in the model than less important areas such as lower wind speed; unpredictive or unsuitable map classes such as DOC land can be assigned very low weights to downgrade resulting suitability. The eleven weighted predictive maps we created were combined using a series of fuzzy operators as shown by the modelling scheme below. This created a single map showing ideal regions for wind turbines in Wellington.



Fuzzy logic modelling scheme


Wind turbines predicted by our model at Meridians Project West Wind

Model Results & Land Management

We have found targets for orogenic gold and wind energy throughout Wellington. The models have located historic mines and current turbines validating our modelling technique. The highest potential for orogenic gold is the Terawhiti Hill area west of the Terawhiti Fault. This area contains archaeological heritage sites; several rare native coastal plants and seabird nesting sites; and is visible from a coastline considered to hold high scenic value in Wellington. These considerations, along with the small target size and limited prospectivity east of Terawhiti, significantly reduce the potential for economic gold deposits in the region.

The wind energy model has found several ridgelines and open hilltop regions suitable for turbine placement. Although the region has one operating wind farm and others in planning stages, there is excellent potential for further development over areas identified by the model. Only a few model targets fall within the environmentally sensitive area over Terawhiti Hill leaving many suitable targets remaining throughout the region. Most of these are over farm land; are away from metropolitan areas where noise and visual pollution is minimised; are in proximity to major transmission lines; and are near tracks and roadways for easy access.

Our modelling clearly shows that wind energy is currently the most suitable land based resource for the Wellington region. Modelling studies such as these could be applied in other regions for wind, gold, or other resources, to evaluate economic potential. The modelling could help regional planners and explorers assess future developments and manage their assets more effectively.